Canada Mortgage and Housing Corporation
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DEVELOPMENT OF VAPOUR PERMEABILITY DATA FOR WAFERBOARD

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EXECUTIVE SUMMARY

INTRODUCTION

No consistent data base currently exists for the vapour permeance of many building materials. With the development of WALLDRY, CMHC's computer program for simulation of the drying of outer walls, a framework is now available in which this information could be used. As waferboard is one of the most commonl sheathing materials used in Canada, an industry-wide evaluation of the permeance of waferboard is needed. To do so requires information about variability of this property. This study provides the preliminary information on which to base the collection of a more extensive data base.

OBJECTIVE

The objective of the present study is to provide information on variability in permeance within panels, between panels, and between manufacturers. Some information is also sought on the differences between manufacturers and the influence of thickness of material.

SCOPE

A limited experimental design was established for material from 6 manufacturers; most of the data was obtained for the wet-cup permeability test. Some data was also obtained using the dry-cup test and the saturated sample test.

METHODOLOGY

A test sample holder was developed to allow the testing of relatively large specimens so that the variability of samples taken from any one panel would be minimized. A limited experimental plan allowed for the examination of variability in permeance within panels and between panels.

RESULTS

The variability in permeance both within panels and between panels was found to be high despite use of a large specimen size. While some of this variability was attributed to density variations, heterogeneity of the product and other production parameters were thought to contribute to this variation. It was suspected that oriented waferboard had higher variability than ramdom waferboard. Dry-cup tests gave permeance values that were lower than the wet-cup test values, but too few samples were tested to assess the relative magnitude of the two results considering the variability. Saturated sample tests showed that liquid flow through a sample and evaporative loss from its face lead to a loss of water from the sample that was over 100 times that found in wet-cup tests by vapour transmission alone. Retesting of redried material showed that a permanent change in permeance had taken place as a result of swelling of the material on absorption of moisture. Approximately 60 percent higher permeance was found for two specimens that were retested after being redried. The waferboard tested was over 6 times more permeable to the passage of water vapour than presently assumed in the program WALLDRY.

CONCLUSIONS

The database obtained in this preliminary study provides insight into the variability in vapour permeability of waferboard. It does not provide sufficient information to represent the industry norms for this property. However, it will permit design of industry-wide studies of permeability for a range of thicknesses currently used as wall sheathing to allow simulation studies to be carried out using CMHC's computer program WALLDRY.

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1.0 INTRODUCTION

1.1 BACKGROUND

The CMHC study on drying of walls in Atlantic Canada (1) has shown that green lumber framing will dry very slowly when the outer sheathing has low vapour permeability. Waferboard, for which there is little data on its vapour permeability, is commonly used as a sheathing material. Given that the vapour permeability of waferboard can be low compared to some other building materials, it is considered important to secure consistent, broadly-based, permeability data for this material. The data would be of use to both the waferboard industry and building scientists for simulation of wall performance using the computer model WALLDRY currently being developed by CMHC for investigating the drying potential of outer walls.

Forintek Canada Corp. undertook this investigation with financial support provided by CMHC to provide an initial data base on the permeance of waferboard materials and to assess factors that would be of use in planning subsequent studies on this subject.

1.2 OBJECTIVES

The broad objectives of the present study are to examine the variability in vapour permeability of waferboard, both within and between panels, and to assess the influence of panel thickness. The specific objectives included in this work are the following:

(a) to develop a test holder for measuring the vapour permeability of a relatively large area of panel material. For materials possessing low vapour permeability, use of a large specimen is desireable to increase the accuracy of measurement and to minimize the variability in the data. A prototype holder had already been developed, and it was to be improved upon in this work. A sufficient number of holders were then to be fabricated to accomplish the work in this study.

(b) to determine dry-cup and wet-cup permeability rates for a range of thicknesses of waferboard from different manufactures. The materials for this work were retained from other material property tests at Forintek Canada Corp. This data will provide some idea of the variability of permeability both within panels from one manufacturer and between manufacturers.

(c) to investigate an additional test called the saturated-sample test. The mode of moisture transport through hygroscopic materials, including waferboard, is altered when contact is made with water. Liquid transport by capillary action dominates. The material swells both in its thickness and in its plane and it becomes permanently altered. In this test, a supply of water will be provided to one side of the waferboard specimen while evaporation takes place on the opposite side.

The data from both (a) and (b) will be used for input to the computer program WALLDRY. The work from (c) may be of assistance in assessing whether moisture transport algorithms used in the computer program are relevant after the material absorbs and retains high levels of moisture.

1.3 SCOPE

The time allocated and the funding provided for this work are not sufficient to undertake a full experimental design for all types of tests outlined in the objectives stated above. The intent then, is to undertake a limited experimental plan to provide information that will allow a more detailed study to be undertaken later, possibly with funding by the industry; yet -- within the scope of this study -- to provide preliminary data that can be of use in the material properties data base incorporated in the CMHC computer program WALLDRY and for assessing algorithms assumed in the model.

2.0 DEVELOPMENT OF A SAMPLE HOLDER

2.1 GOAL

Procedures and test apparatus used for permeability testing are covered in ASTM E96-80 "Water Vapor Transmission of Materials". These procedures provide for the evaluation of small samples of material using relatively small test holders, and larger samples in relatively larger flat containers. Techniques for sealing the edges of the test samples are also described which involve using foil tape and/or wax seals.

For the so-called wet-cup test, in which the sample is exposed to a high relative humidity (RH) on one face, the disadvantage of using a shallow specimen holder is that the water bath contained within it may get the sample wet during handling of the sample during test. Wetting may not present a problem to materials whose properties are unaffected by contact with water, but this would not be desireable for a hygroscopic material whose properties are altered by direct contact with water. The standard makes provision for various techniques for preventing sloshing. For example, a sample holder whose interior construction included a series of baffles would allow handling of the specimen and its container with less danger of directly wetting the test material. The larger the size of the sample, the more critical this becomes.

Given that the variability of material properties may be large, and the weight loss or gain may be small for thicker materials or low permeability materials, and recognizing that the tests are of long duration, it follows that it is desireable to use larger-sized samples for characterizing the vapour permeability of these building materials. It is also desireable that the weight of the sample holder and the water bath (in the case of the wet-cup test) together with the sample itself be moderately low so that the weight loss or gain can be accurately measured with a moderately precise electronic balance.

Forintek Canada Corp. developed a sample holder that would allow this goal to be achieved.

2.2 SAMPLE HOLDER DESCRIPTION

Producing a low-weight sample holder can be accomplished in various ways. The sample holders which were developed consist of relatively low-cost 12-cup muffin trays as the basic holder for water or desiccant, depending on the test being conducted. The muffin trays were painted with two coats of a rust-resistant paint on all surfaces to control degradation of the tray material as well as to seal the trays where the individual cups were crimp-folded to the rest of the tray. The muffin tray was placed in a 22-gauge galvanized steel frame to which it was fixed with brass bolts. The seal between the frame and the muffin tray was achieved with butyl caulking. All holes through the muffin tray and the galvanized frame through which bolts passed were fitted with rubber gaskets. Twenty seven holders were fabricated for this study.

The completed sample holder is shown in Figure 1. Detailed measurements of this design are given in Figure 2.

2.2.1 Edge Sealing Method

The size of the test specimens was 287 mm by 378 mm. The edges of the specimen were taped from each side as shown in Figure 3, providing for a covered edge width of approximately 15 mm. The tape used for this experiment was 3M Construction Tape commonly used for taping building house wrap air barriers. Taping was done from both faces and overlapped on the edges of the specimen.

On installation in the holder, the specimen rested on three brass bolts screwed through the sides of the specimen holder to provide three-point support for it. The same tape material was used to tape the prepared specimen to the body of the specimen holder as shown in Figure 4. The

specimen was recessed below the top of the sides of the specimen holder. As a result, at re-entrant corners where it was more difficult to effect a tape seal, a hot thermoplastic adhesive was used there to supplement the tape seal.

The width and length of the specimen was approximately 2 mm less than the opening provided in the specimen holder. The tape seal of the specimen to the body of the holder provided flexibility to allow expansion of the specimen without loss in continuity of the vapour seal. The only points of semi-rigidity were at the corners where the strippable thermoplastic adhesive had been used to complete the seals. Therefore, it was felt that sufficient flexibility existed to maintain continuity.

2.2.2 Sample Holder Evaluation

On completion of fabrication, all sample holders were tested for gross leaks by filling them with water. Any leaks found in this way were then sealed by use of additional butyl caulking around the perimeter of the muffin tray or by adding a closed cell plastic foam tape at bolt locations. These trays were then retested to assure that no leaks existed in the main body of the holders.

A further test was then made by positioning a galvanized steel plate in place of a sample. It was taped in place as would be done with test material and the weight change was monitored. This effectively assessed the sealing technique and the specimen holder.

2.2.3 Measurement of Metering Areas

Taping the edges of the specimen in the manner described provided for a metering area of approximately 0.089 m^2. The actual area of each specimen was measured by measuring the dimensions of all four sides of the exposed area, as well as the diagonals. The area was calculated using each diagonal measurement and the side measurements to obtain two

independent values for the exposed area, which were then averaged. The difference between the two calculated areas was also compared to assure that there was no gross measurement error in any one of the measurements.

The calculation for area was done as follows, referring to Figure 5 for the definition of dimensions. In the equations, a three-letter designation, for example ACE, refers to the area of the triangle defined by these letters. A two-letter designation represents the distance between the two points defined by those letters.

$$AREA = [(ACE + ADF) + (DAC + DFC)] / 2$$

where
$$ACE = [k_1 \cdot (k_1 - AC) \cdot (k_1 - CF) \cdot (k_1 - AF)]^{0.5}$$
$$ADF = [k_2 \cdot (k_2 - DF) \cdot (k_2 - AD) \cdot (k_2 - AF)]^{0.5}$$
$$DAC = [k_3 \cdot (k_3 - DF) \cdot (k_3 - CF) \cdot (k_3 - DC)]^{0.5}$$
$$DFC = [k_4 \cdot (k_4 - AC) \cdot (k_4 - AD) \cdot (k_4 - DC)]^{0.5}$$

and
$$k_1 = (AC + CF + AF)/2$$
$$k_2 = (DF + AD + AF)/2$$
$$k_3 = (DF + CF + DC)/2$$
$$k_4 = (AC + AD + DC)/2 .$$

Since there was a possibility that the tape might not be installed perfectly straight, so that the computed area might be smaller or larger than the actual area, two additional measurements were made, each across the mid-points of the sides. If the mid-side measurement deviated from the mean of the two outside measurements this implied that there was curvature in the taped edge and it was assumed that this varied parabolically. The correction for curvature in the sides was obtained with the following expression.

$$A_{cor} = [\ BE - (AD+CF)/2\ ] \cdot (AC+DF)/2 \cdot 2/3$$

$$+ [\ GH - (AC+DF)/2\ ] \cdot (AD+CF)/2 \cdot 2/3$$

and the corrected area $AREA_{cor}$ was,

$$AREA_{cor} = AREA + A_{cor}$$

The correction was positive or negative depending on the direction of the curvature of the taped edge. These additional measurements were made for the first 25 specimens tested in order that error analysis could be done to demonstrate whether these corrections were necessary.

In addition, the metering area was measured before and after each test. This was done to assess how much change occurred in the computed permeability based on whether before-test or after-test areas were used for the material being evaluated.

3.0 EXPERIMENTAL PLAN

The property of most interest to this study is the ability of waferboard to rid a wall of vapour from enclosed cavities. Consequently, the wet-cup test was chosen for the majority of the tests planned. The variability in permeance within panels, between panels, between thicknesses, and between manufacturers need not be studied in detail for all permeability tests. It is possible that one or another panel may be more stable in the presence of moisture, and that a change in vapour permeability will take place on redrying that may be different from one manufacturer to another. At this stage, too many factors exist to run a complete experimental plan for both the wet and dry cup tests. A relatively thorough examination for one test type should help guide the design of subsequent test series.

Waferboard panels from six different mills were available, and with a different number of thicknesses from each mill. The greatest variety of panel thicknesses was available from one manufacturer whose products were chosen as a base for the majority of the investigation. The material from the other manufacturers was all evaluated using a panel thickness of 11.1 mm, one that is commonly used in both roof and wall sheathing. This is not the minimum thickness permitted for wall sheathing by the National Building Code of Canada; however, this thickness is often used.

To study within-panel and between-panel variability, two thickness were assessed (7.9 mm and 11.1 mm), using five specimens from each of four panels for each thickness. This required a total of 40 specimens.

The influence of thickness was assessed using five specimens from one panel each of five waferboard thicknesses (7.9, 9.5, 11.1, 12.7, and 15.9 mm). This examination required the testing of 25 specimens.

Finally to assess the variability between manufacturers, two specimens from each of two panels, for 6 manufacturers of 11.1 mm waferboard were planned. This required testing an additional 20 specimens. In all cases, where there was overlap in the design, advantage was taken of this fact to minimize the number of tests required.

A summary of this experimental plan is provided in Table 1.

The base examination was done using oriented strand board. This is waferboard in which the wafers are moderately aligned on the faces in the long direction of the panel, while the interior core layer is oriented in the other direction. Some manufacturers orient both core and face layers, while others orient only the face layers. The interior core in this latter case is randomly formed in the mat before pressing. For the between-manufacturers examination of variability in the permeance of 11.1 mm waferboard, both oriented and random board were represented, the latter being manufactured using randomly laid wafers

throughout the entire thickness. Three out of the six mills included in this examination produced randomly oriented waferboard.

4.0 TEST METHODS

4.1 Wet-cup Tests

Testing generally followed ASTM E96-80 methods with several exceptions. For the wet-cup testing, approximately 50 ml of water was put into each cup in the tray. The sample holders were positioned on shelves in an open rack. The conditions in the laboratory in which the samples were tested was conditioned at 50 percent RH ± 1.0 and 22°C ± 1°. Figure 6 shows the samples conditioning in the laboratory.

The total weight of each holder and specimen was monitored on a daily basis until it appeared to reach near uniform weight loss. After this time, weight readings were made twice daily. The precision of the scale used for these measurements was 0.1 g and the average mass of the tray and sample at the beginning of test was in the order of 3500 g.

Based on the experience of these tests, it took 14 days before linear weight loss was experienced. Two weeks of recording weight loss followed. Generally, the maximum residuals were in the order of 0.15 g and the standard error was 0.05 g. The coefficient of determination of 0.999 or higher was typically obtained for the regression of weight loss against time. The total test duration of about 24 days was required for most specimens.

On completion of a test, each sample holder was cleaned out with a mild ammonia solution, and then rinsed with clean water and dried. The waferboard samples were saved and allowed to recondition under laboratory conditions of 65 percent RH and 21° C for possible retesting at some future time.

4.2 Dry-cup Tests

A false bottom was installed inside the sample holders on which anhydrous calcium chloride crystals were placed in sufficient quantity to absorb the moisture expected and to maintain the required dehydrating conditions throughout the test period. This brought the top level of the crystal bed closer to the underside of the test specimen. The test duration necessary was the same as for the wet-up tests. These tests were done at the same time as the wet-cup tests and under the same laboratory conditions. The specimen holder was shaken after each weight reading to mix the crystal bed inside. Weight readings were taken to provide data for at least two weeks of steady state conditions.

4.3 Saturated-sample Tests

Originally, it was intended that these tests be done as inverted-cup tests, i.e., that the wet-cup test be continued by turning the specimen holder upside down. Considering the swelling of the specimen that would take place, with the potential for disruption of the edge seal, specimens were preconditioned to saturation instead, thereby saving time as well.

The specimens were soaked in distilled water for a two week period during which time they acquired most of the water that would ultimately be absorbed. They were then placed in a chamber filled with tap water and subjected to a vacuum-pressure cycle to complete their take-up of water. Finally they were immersed in distilled water until required for test.

The faces were wiped dry and the edges taped as for the wet-cup tests. Cellulose sponges were placed in the specimen holder over the entire area and the sample holder was filled with distilled water so that when the specimen rested on the sponges, the level of water in the space between the specimen and the tray was just under the top surface of the

specimen. The specimen was then sealed into place with tape as for previous tests. The tape-to-tape seal, and the tape-to-tray seal were effective because the surfaces could be wiped dry.

Equilibrium in vapour loss from the top surface was attained in one week and two weeks of weight loss measurements followed.

5.0 RESULTS

5.1 Testing Techniques

Circulation of air around the specimens was not strictly controlled except for that provided by the large distribution exhausts positioned throughout the laboratory. To assess if this was important, after one series of samples had attained steady state vapour flow and sufficient weight loss data had been obtained to calculate the permeance, small fans were set up to direct an air stream at the top surface of each specimen and weight loss measurements were continued for one additional week. There was no change in the calculated permeance at the third significant digit using data for the third week only and it was concluded that sufficient air flow occurred in the laboratory around specimens to prevent formation of a stagnant air film at the specimen surface. As an example of the typical results obtained, a plot of weight loss versus time is shown for one specimen in Figure 7 for the wet-cup test.

The metering area measured on the exposed side and the source side was not the same. The areas were calculated for both sides of 25 specimens prior to test. It was found that there was an average difference in area of 0.38 percent using the exposed surface as a reference with the sign of the difference being negative 20 out of 25 times. Since the permeance is controlled largely by the rate at which vapour can exit from the specimen on the drier face and since the permeability is lower on that face, it was decided that the exposed face should be used for

computation of permeance. It was also concluded that the difference in area was small and that the tape application technique was satisfactory.

By using only the straight edge dimensions for computing area, and measuring the exposed face before and after wet-cup tests on 25 specimens immediately on conclusion of the test, it was found that an average linear expansion of 0.14 percent had taken place. This represents a relatively small difference and suggests that either the before-test or after-test area could be used for the calculation of permeance. Since the vapour transmission rate is controlled by the area of the exposed face during steady state weight loss, it was decided to measure the area of the exposed face only at the conclusion of the test in subsequent work.

The error in assuming taped edges to be straight was also assessed for these 25 specimens at the conclusion of the wet cup tests. The correction in area for non straightness of the taped edges ranged from -0.58 percent to +0.81 percent with 20 out of 25 corrections being positive, i.e., the corrected area was larger than the uncorrected area, on average. On the basis of this experience, it was decided to include the correction for curvature since the error approached one percent for some specimens.

5.2 Wet-cup Test Results

The test results for all wet-cup tests are provided in Tables 2 and 3. Normally, the permeability of thin materials is not provided. In this experiment, given the range of thicknesses included, the permeability has also been calculated. The initial thickness of two complete sets of specimens tested was not measured nor their initial densities obtained. Consequently, the permeability for these specimens has been based on the nominal thickness of the specimens in question. The permeability based on measured initial thickness is also provided for those specimens for which the information was available.

Examining Table 2 in which the test data for a range of thicknesses is provided for oriented waferboard from Mill A it is seen that within-panel variability was high. The coefficient of variability (COV) ranges from 4.9 percent to 50.4 percent for individual panels. Most of the data was obtained for 7.9 mm and 11.1 mm board material, there being 5 specimens from each of 4 panels. The standard deviation over each group was 45.1 and 43.8 metric perms which represented 22.4 and 36.8 percent COV respectively. The variability in permeance of individual panels was as low as 4.9 percent in one case. In other cases, it appears as if some specimens had a permeance that was half or less that for others cut from the same panel. This suggests that the panels are highly heterogeneous.

The data in Table 3 represents all tests on 11.1 mm board from 6 mills. While the number of specimens in each group was different, particularly for Mill A, it is noted that the standard deviations are higher for oriented waferboard than for random waferboard. The standard deviations in permeance for oriented board (mills A, D, and F) were 43.79, 42.80, and 41.43 metric perms respectively, while those for random board (mills B, C, and E) were 6.27, 19.37, and 31.75 metric perms respectively. While it appears that a random layup results in a more uniform distribution of material and a more uniform resistance to vapour transmission, it is not possible to be conclusive on this point. The within-panel variability is not fully represented using only two specimens from each panel.

A plot of permeance versus specimen thickness for material from Mill A is shown in Figure 8. The means are shown as solid squares, and these have been joined by a dotted line. As expected, the permeance decreases as the thickness of material increases. A plot of permeability, calculated on the basis of nominal thickness, versus panel thickness is shown in Figure 9. Also, as expected, there appears to be a trend of decreasing permeability with increasing thickness. Presumably, a larger thickness could result in greater uniformity of resistance to vapour flow. Also, the process variables for each board thickness are

different and this results in different density gradients from the surfaces to the core. Thicker panels are laid up with orientation of wafers in the core at right angles to those in the faces, or randomly, resulting in higher overall resistance per unit thickness of material.

5.3 Dry-Cup Test Results

Only three values for this test were obtained and only for 11.1 mm thickness material from Mill A. These are summarized in Table 4. Little can be said about the variability except that it was low. If the mean of 54.9 metric perms were truly representative of that material, it would be compared with a value of 118.9 metric perms found for the wet-cup test. Given the variability found for the latter, it would be rash to conclude that the ratio between them was true. Based on published behaviour of hygroscopic materials, a lower permeability should be expected but the actual mean value cannot be determined from so few tests.

5.4 Saturated-sample Test Results

The order of magnitude of vapour leaving the specimen surface in this test is many times greater than for the wet-cup test. The results for 4 tests of 11.1 mm material from Mill A are also given in Table 4. The permeance noted is not so much a vapour permeance but a liquid permeance controlled by the rate of evaporation from the top surface of the specimen. The mean value of 12880 metric perms is over a 100 times larger than the mean for the wet-cup test of similar material from this mill. This suggests that continued condensation on one face of this material could lead to fairly rapid removal of the water, provided evaporation was not restricted by the presence of other materials.

A plot showing the relative magnitude of the rates of vapour loss from the top surface of specimens for each type of test conducted in this report is given in Figure 10.

6.0 DISCUSSION

The data presented in this report have not examined the influence of other factors. Sufficient data to study the effect of density variation is only available for the wet-cup tests, and this is limited to 5 mills, but not including Mill A for which most of the data was obtained. The initial study plan did not include measurement of certain variables, including initial weight. It was only after the first two sets of tests were completed that these measurements were included.

Based on data for 30 tests, permeance was significantly influenced by thickness and board density, and mill source at or under the 5 percent probability level. Permeability however was significantly influenced by thickness and density only at the 10 percent probability level, while mill source was significant at the 0.5 percent probability level. It would be desireable to be able to say that permeability was not affected by thickness so that a single value could be used for all material produced by a particular mill. However, as has already been observed, the data is very limited and too few values are available to be able to assume that they represent permeance properties for the production there. Indeed, based on the variability in permeance for two thicknesses from Mill A, it would be necessary to have a great deal more information to draw definitive conclusions about the influence of thickness and density of specimens, and layup of wafers on the permeability of different waferboard products.

The data summarized in Table 2 for 7.9 mm waferboard provides a mean value of 201.5 metric perms (ng $Pa^{-1}s^{-1}m^{-2}$). The equivalent diffusion resistivity, which is the inverse of the permeability based on the product thickness before test, was 628 x 10^9 [(m^2 s Pa/Kg)/m]. This mean is approximately 6 times smaller than has been assumed for plywood and particleboard in the data base presently used by WALLDRY (3). The value used was 3906 x 10^9 [(m^2 s Pa/Kg)/m], the source for which was the ASHRAE Handbook (4) for Douglas-fir plywood with exterior glue

lines and was based on tests of 6.4 mm thick material. The lower value obtained in this experiment implies that a greater quantity of water vapour can pass through this thickness of waferboard than would be assumed by the computer program.

The test values noted in the ASHRAE Handbook for plywood were obtained using neither the wet-cup or dry-cup test but one of the other means by which permeance can be measured. These other measurements assure that the possibility of condensation of moisture on the underside of the specimen during a test do not occur. It was not possible to guarantee that this did not happen in the tests reported in the present study. Considering that the real behaviour of materials in walls in a fluctuating temperature and moisture environment will likely lead to that possibility, this information may be of more use than that from tests in which this cannot happen. In any case, the dry-cup tests provide a lower bound to assess the relative magnitudes of the two test types and values likely to be obtained by other test methods.

Finally, each test type results in a different degree of swelling of the waferboard. Limited thickness measurements before and after test were done. Based on 11 specimens of 11.1 mm board, 10.3 percent swelling was found, and the variation across the 5 manufacturers was low, there being only a 5.7 percent COV. For three dry-cup test values, there was a shrinkage of 0.25 percent, while for 4 saturated-sample tests, there was a 78.9 percent expansion in thickness. The thickness expansion signifies a permanent change in the internal structure of the material, and it is expected that repeated tests on the sample would produce different, probably higher, permeance values. A wet-cup retest was done for two specimens after reconditioning back to moisture equilibrium with the laboratory air. The retest values were approximately 60 percent higher than before. It is suspected that the dry-cup permeance of redried material would be significantly increased. Mathematical modeling of the performance of walls in which condensation has occurred should account for the change in properties of the materials that have been so wetted.

7.0 CONCLUSIONS

The following conclusions were made from this pilot study of permeance of waferboard from 6 mills of various thicknesses.

(1) The test procedures and edge sealing techniques proved to be satisfactory for each test type.

(2) Density variation helped explain some of the difference found from one sample to another, however fairly large within-panel variability was found. It was recognized that some of this was due to orientation of wafers, and other process variables.

(3) The variability of permeance for one thickness of waferboard within panels and between panels suggests that a significantly higher number of panels should be sampled with fewer samples per panel than used in this study to characterize the permeance for a waferboard panel product such as waferboard.

(4) When waferboard is saturated, liquid flow through the material, and evaporative vapour loss from the surface was about 100 times larger than the rate found for the wet-cup test.

(5) The dry-cup test results were lower than for wet-cup tests, but too few results were available to assess the absolute relative magnitude for the panel type tested.

(6) Based on the limited data, the permeance of 201.4 metric perms for the 7.9 mm waferboard was about 6 times higher (and the diffusion resistivity lower) than presently assumed for wood-based sheathing in the computer program WALLDRY used for simulating the drying out of outer-wall elements.

(7) Retesting of redried material showed that a permanent change in properties of the material had occurred. The permeance was approximately 60 percent higher than before, i.e., between 9 and 10 times higher than now assumed in WALLDRY.

8.0 RECOMMENDATIONS

It is not the purpose of this report to recommend a specific sampling program for ingrade determination of permeability of waferboard materials. However, the following recommendations are made to assist with the planning of such studies.

(1) Broader sampling of panels should be used with fewer samples per panel, with random selection of specimens cut from within panels.

(2) Wet-cup tests provide the most useful information for wall modeling.

(3) Retesting of redried specimens should be included in any large study of permeance of hygroscopic materials such as waferboard to assess in-service changes in material properties.

(4) Dry-cup tests of redried material are likely to be of greater use than those done on fresh material. Limited investigation of the order of magnitude change would prove of use in modelling wall performance.

9.0 REFERENCES CITED

1. Oboe Engineering Ltd. 1987. Final report on the drying of walls-Atlantic Canada. prepared for Canada Mortgage and Housing Corporation, Ottawa.

2. ASTM. Standard Test Methods for Water Vapor Transmission of Materials. E 96 - 80.

3. Rowan Williams Davies & Irwin Inc, and Scanada Consultants Limited. 1988. Drying characteristics in outer walls of low-rise residential housing. Final Report 487-1400-1. submitted to Canada Mortgage and Housing Corporation, Ottawa .

4. ASHRAE Handbook, 1985 Fundamentals. American Society of Heating, Refrigeration and Air-Conditioning Engineers Inc. Atlanta.

Table 1. Summary of Experimental Design

Manufacturer (Orientation)[#]		A (0)	B (0)	C (0)	D (R)	E (R)	F (R)
Nominal Thickness (mm)	Test Type						
7.9	wet-cup	4 (5)*					
9.5	wet-cup	1 (5)					
11.1	wet-cup	4 (5)	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)
	dry-cup	2 (2)					
	saturated sample	2 (2)					
12.7	wet-cup	1 (5)					
15.9	wet-cup	1 (5)					

[#] O = oriented layup of wafers ; R = random layup of wafers

* No. of Panels (No. of Specimens)

Table 2. Wet-cup permeance for five thicknesses of waferboard produced by Mill A.

Nominal Thickness	Panel	Specimen	Permeance (ng/(Pa.s.m²))	Mean	Standard Deviation	Permeability* (ng.m)/(Pa.s.m²)	Mean	Standard Deviation
7.9	1	1	163.0			1.288		
7.9	1	2	230.2			1.819		
7.9	1	3	179.5			1.418		
7.9	1	4	181.0			1.430		
7.9	1	5	182.5	187.2	25.30	1.441	1.479	0.1999
7.9	2	1	206.6			1.632		
7.9	2	2	229.6			1.814		
7.9	2	3	245.9			1.942		
7.9	2	4	179.4			1.418		
7.9	2	5	232.6	218.8	26.17	1.837	1.729	0.2067
7.9	3	1	162.4			1.283		
7.9	3	2	146.5			1.157		
7.9	3	3	146.8			1.160		
7.9	3	4	145.4			1.149		
7.9	3	5	142.6	148.7	7.27	1.127	1.175	0.0616
7.9	4	1	202.6			1.601		
7.9	4	2	270.8			2.139		
7.9	4	3	240.1			1.897		
7.9	4	4	250.1			1.976		
7.9	4	5	291.4	251.0	33.47	2.302	1.983	0.2644
9.5	1	1	98.1			0.932		
9.5	1	2	186.0			1.767		
9.5	1	3	145.2			1.380		
9.5	1	4	180.5			1.715		
9.5	1	5	110.9	144.2	39.66	1.054	1.370	0.3768
11.1	1	1	153.5			1.704		
11.1	1	2	94.3			1.046		
11.1	1	3	170.6			1.894		
11.1	1	4	122.9			1.364		
11.1	1	5	116.1	131.5	30.45	1.289	1.459	0.3380
11.1	2	1	113.7			1.262		
11.1	2	2	93.2			1.034		
11.1	2	3	105.5			1.171		
11.1	2	5	78.8	97.8	15.22	0.875	1.086	0.1689
11.1	3	1	93.8			1.041		
11.1	3	2	74.7			0.829		
11.1	3	3	75.9			0.843		
11.1	3	4	190.0			2.109		
11.1	3	5	178.3	122.5	56.50	1.980	1.360	0.6318
11.1	4	1	93.2			1.035		
11.1	4	2	223.4			2.480		
11.1	4	3	75.0			0.833		
11.1	4	4	119.3			1.324		
11.1	4	5	87.0	119.6	60.24	0.965	1.327	0.6687
12.7	1	1	72.8			0.925		
12.7	1	2	61.1			0.776		
12.7	1	3	83.2			1.057		
12.7	1	4	99.9			1.269		
12.7	1	5	120.8	87.6	23.43	1.535	1.112	0.2975
15.9	1	1	51.8			0.824		
15.9	1	2	28.0			0.445		
15.9	1	3	82.9			1.319		
15.9	1	4	90.4			1.438		
15.9	1	5	82.9	67.2	26.48	1.318	1.069	0.4210

* Based on nominal thickness.

Table 3. Wet-cup permeance for 11.1 mm waferboard produced by six mills.

Mill	Panel	Specimen	Permeance (ng/(Pa.s.m²))	Mean	Standard Deviation	Permeability* (ng.m)/(Pa.s.m²)	Mean	Standard Deviation	Permeability# (ng.m)/(Pa.s.m²)	Mean	Standard Deviation
A	1	1	153.5			1.704			.		
A	1	2	94.3			1.046			.		
A	1	3	170.6			1.894			.		
A	1	4	122.9			1.364			.		
A	1	5	116.1			1.289			.		
A	2	1	113.7			1.262			.		
A	2	2	93.2			1.034			.		
A	2	3	105.5			1.171			.		
A	2	5	78.8			0.875			.		
A	3	1	93.8			1.041			.		
A	3	2	74.7			0.829			.		
A	3	3	75.9			0.843			.		
A	3	4	190.0			2.109			.		
A	3	5	178.3			1.980			.		
A	4	1	93.2			1.035			.		
A	4	2	223.4			2.480			.		
A	4	3	75.0			0.833			.		
A	4	4	119.3			1.324			.		
A	4	5	87.0	118.9	43.79	0.965	1.320	0.486	.	.	.
B	1	1	65.2			0.723			0.714		
B	1	2	78.1			0.867			0.855		
B	2	1	69.2			0.768			0.785		
B	2	2	77.2	72.4	6.27	0.857	0.804	0.070	0.876	0.807	0.074
C	1	1	173.8			1.929			2.010		
C	1	2	133.7			1.485			1.532		
C	2	1	147.7			1.639			1.682		
C	2	2	171.7	156.7	19.37	1.906	1.740	0.215	1.958	1.796	0.227
D	1	1	76.1			0.845			0.887		
D	1	2	88.9			0.987			1.025		
D	2	1	165.7			1.839			1.898		
D	2	2	142.9	118.4	42.80	1.586	1.314	0.475	1.642	1.363	0.485
E	1	1	120.3			1.336			1.289		
E	1	2	149.1			1.655			1.605		
E	2	1	120.6			1.339			1.352		
E	2	2	187.5	144.4	31.75	2.081	1.603	0.352	2.091	1.584	0.364
F	1	1	197.6			2.194			2.223		
F	1	2	163.1			1.810			1.868		
F	2	1	100.1			1.111			1.065		
F	2	2	135.2	149.0	41.43	1.501	1.654	0.460	1.487	1.661	0.498

* Based on nominal thickness.
\# Based on before test thickness.

Table 4. Dry-cup permeance and saturated sample test results for 11.1 mm waferboard from Mill A.

Test	Panel	Specimen	Permeance	Mean	Standard Deviation	Permeability*	Mean	Standard Deviation	Permeability§	Mean	Standard Deviation
			(ng/(Pa.s.m²))			(ng.m)/(Pa.s.m²)			(ng.m)/(Pa.s.m²)		
dry	1	2	56.8			0.6309			0.6054		
dry	2	1	61.6			0.6836			0.6482		
dry	2	2	46.2	54.9	7.89	0.5126	0.6090	0.0876	0.4939	0.5825	0.0797
sat.	2	6	11110			123.3			130.7		
sat.	2	7	12630			140.2			148.5		
sat.	3	6	14010			155.6			158.0		
sat.	3	7	13760	12880	1324	152.8	143.0	14.70	157.6	148.7	12.77

* Based on nominal thickness.
§ Based on before test thickness.

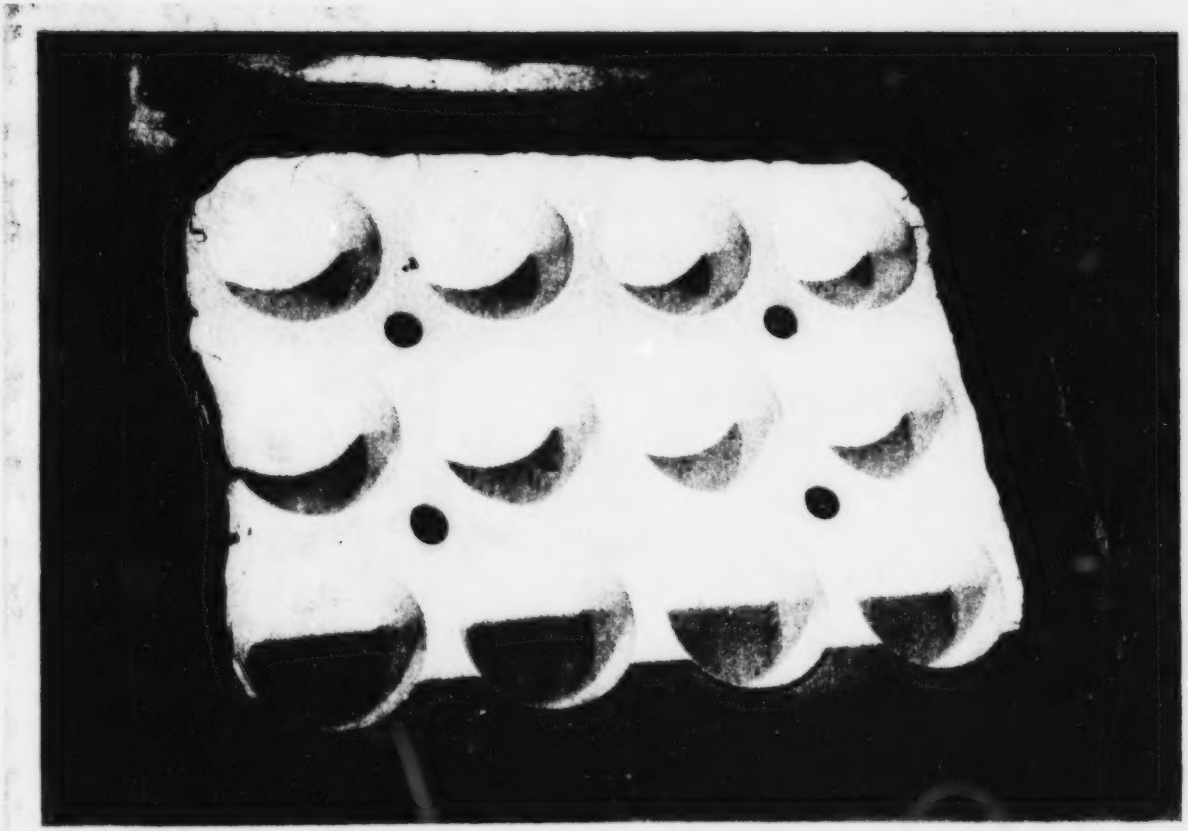
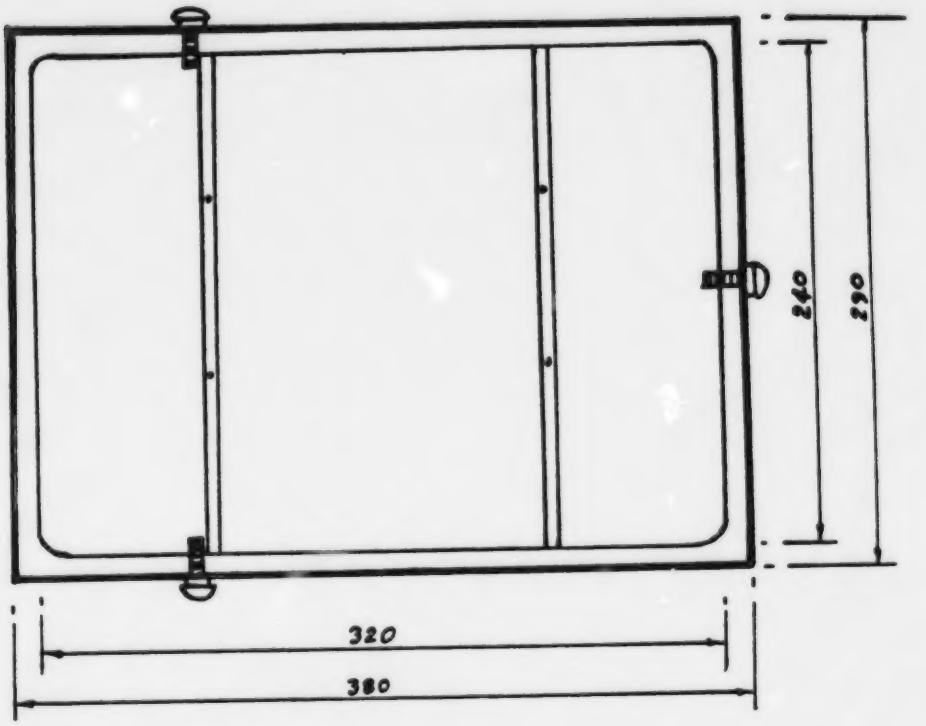


Figure 1. A completed sample holder



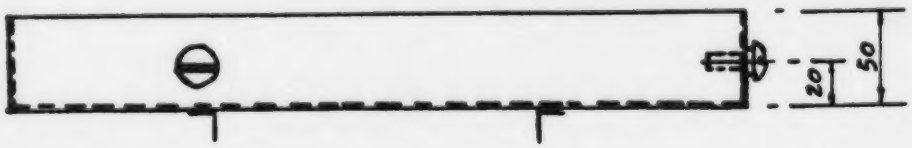


Figure 2. Dimensions of frame for specimen holder

Figure 3. A sample being installed in a sample holder using tape

Figure 4. Preparation of the edge of a specimen prior to installation in the specimen holder

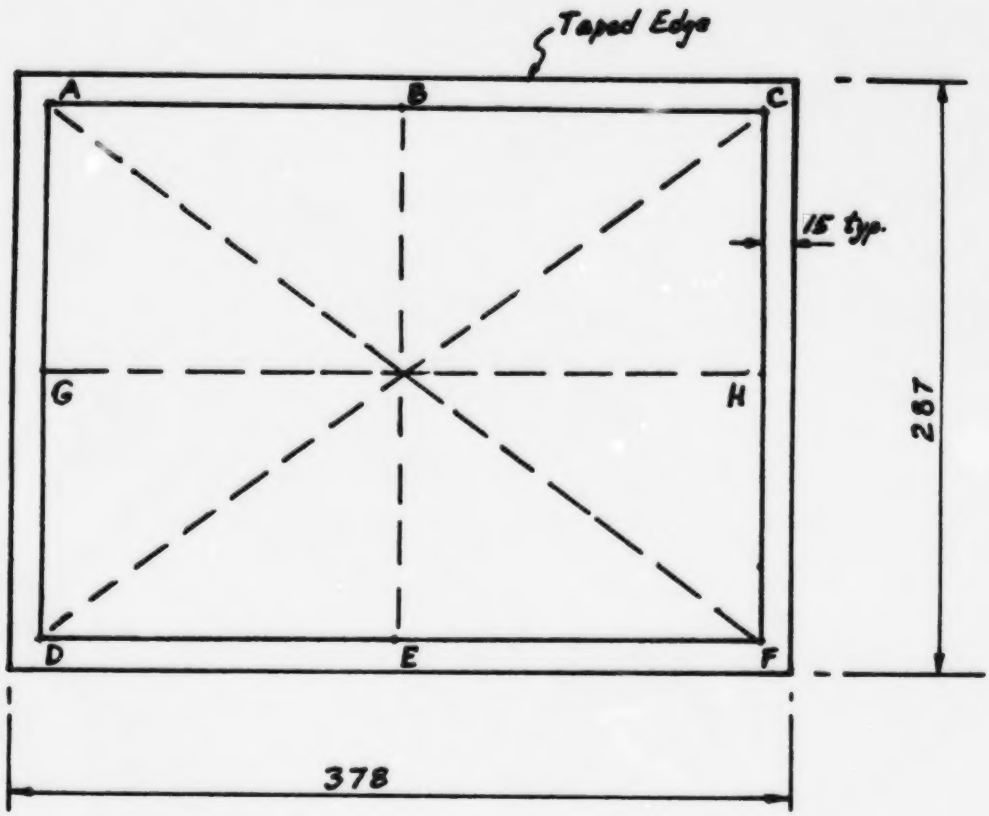


Figure 5. Measurements of metering area

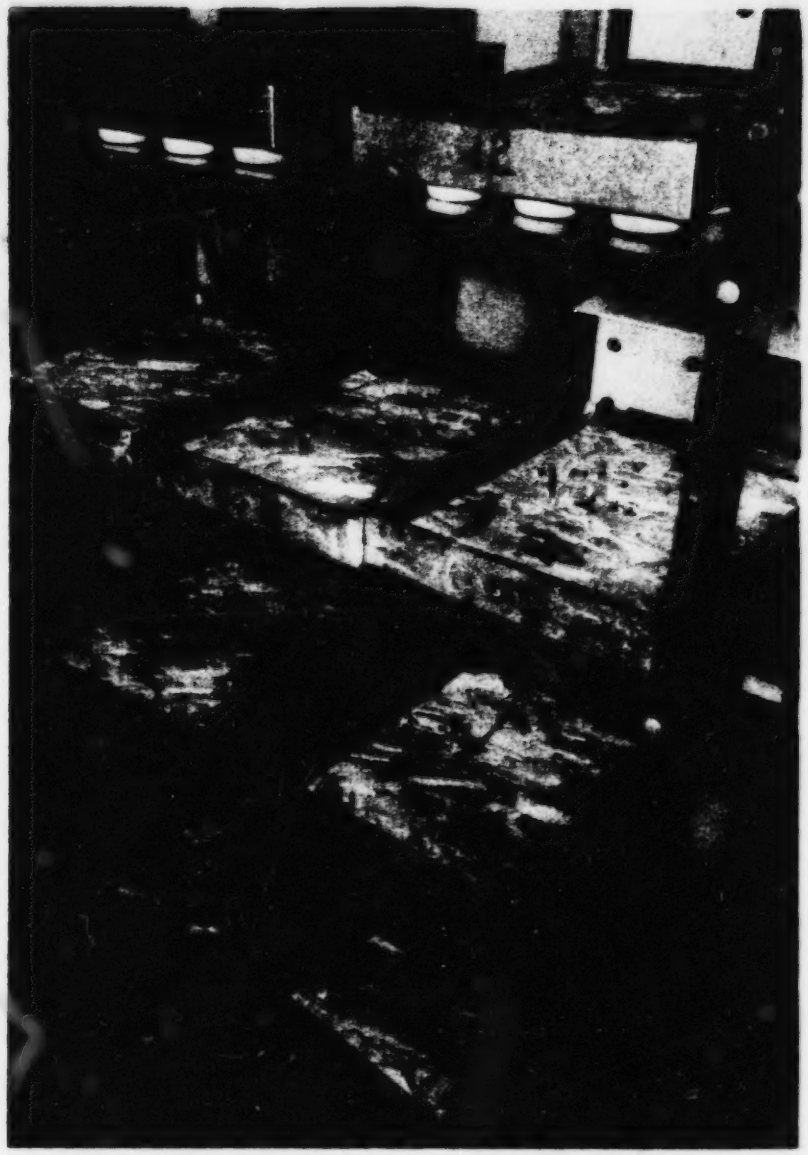


Figure 6. Specimens undergoing test in the laboratory under controlled conditions

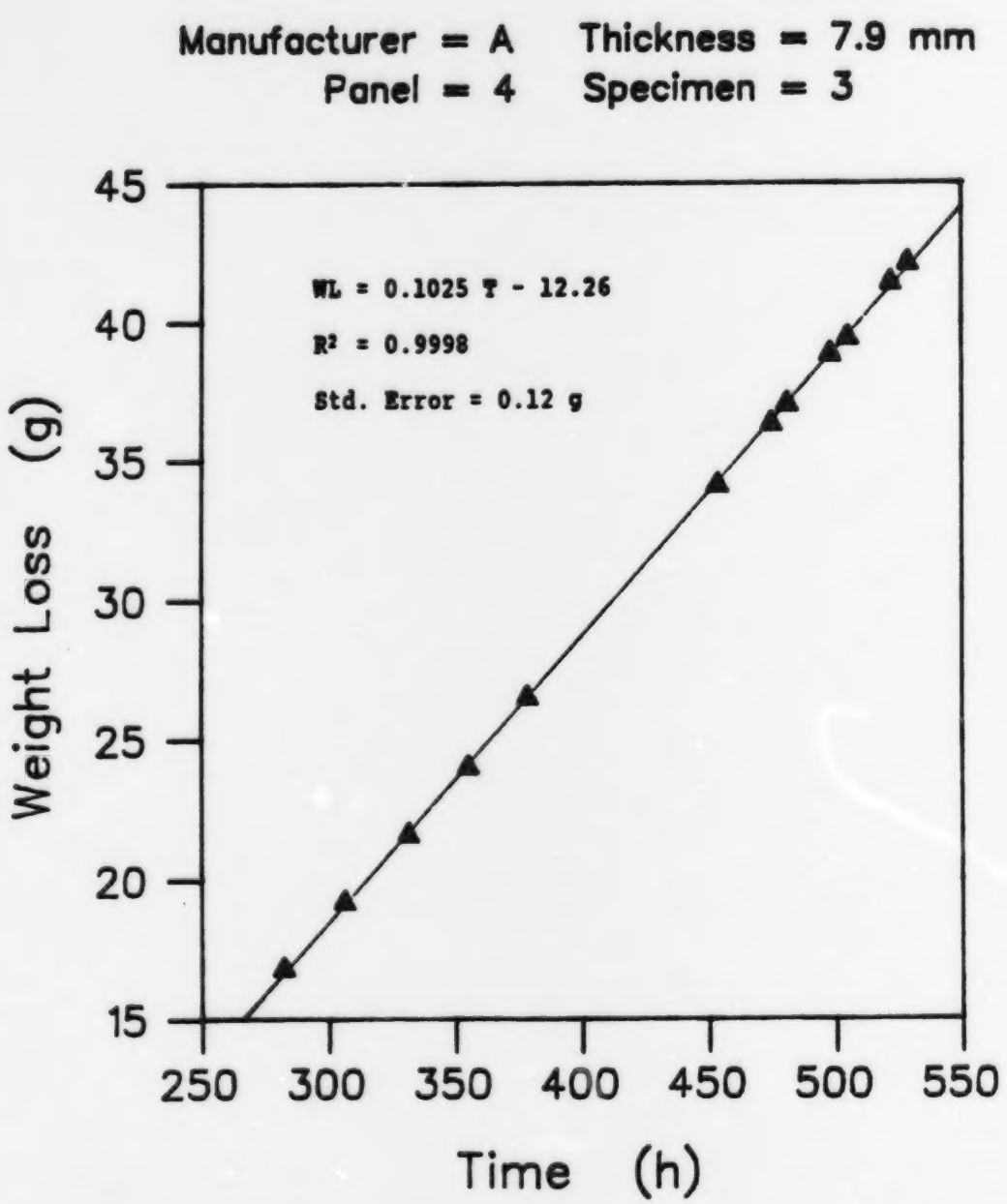


Figure 7. Typical weight loss curve for a wet-cup test

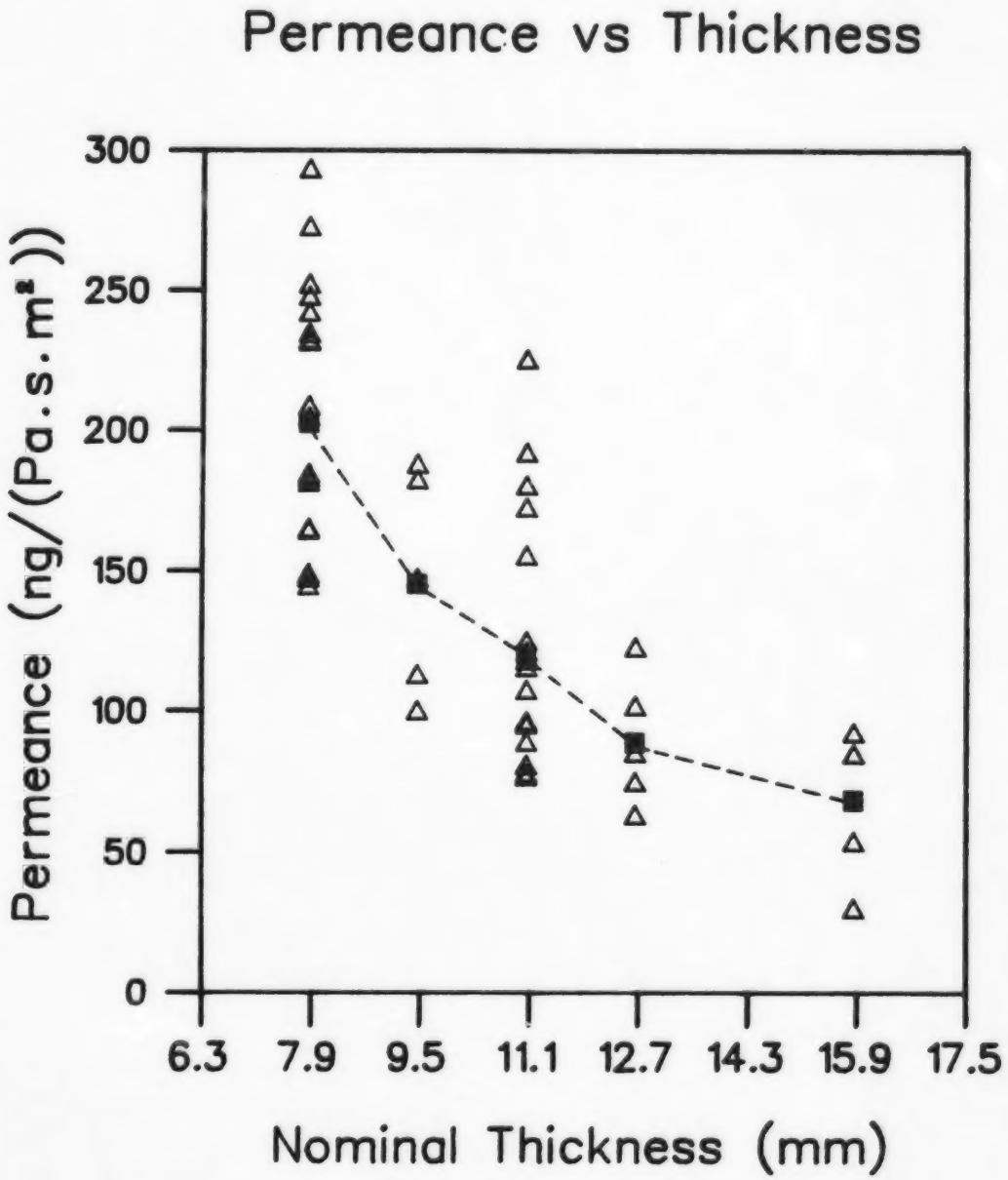


Figure 8. Wet-cup permeance for five thickness of oriented waferboard from Mill A

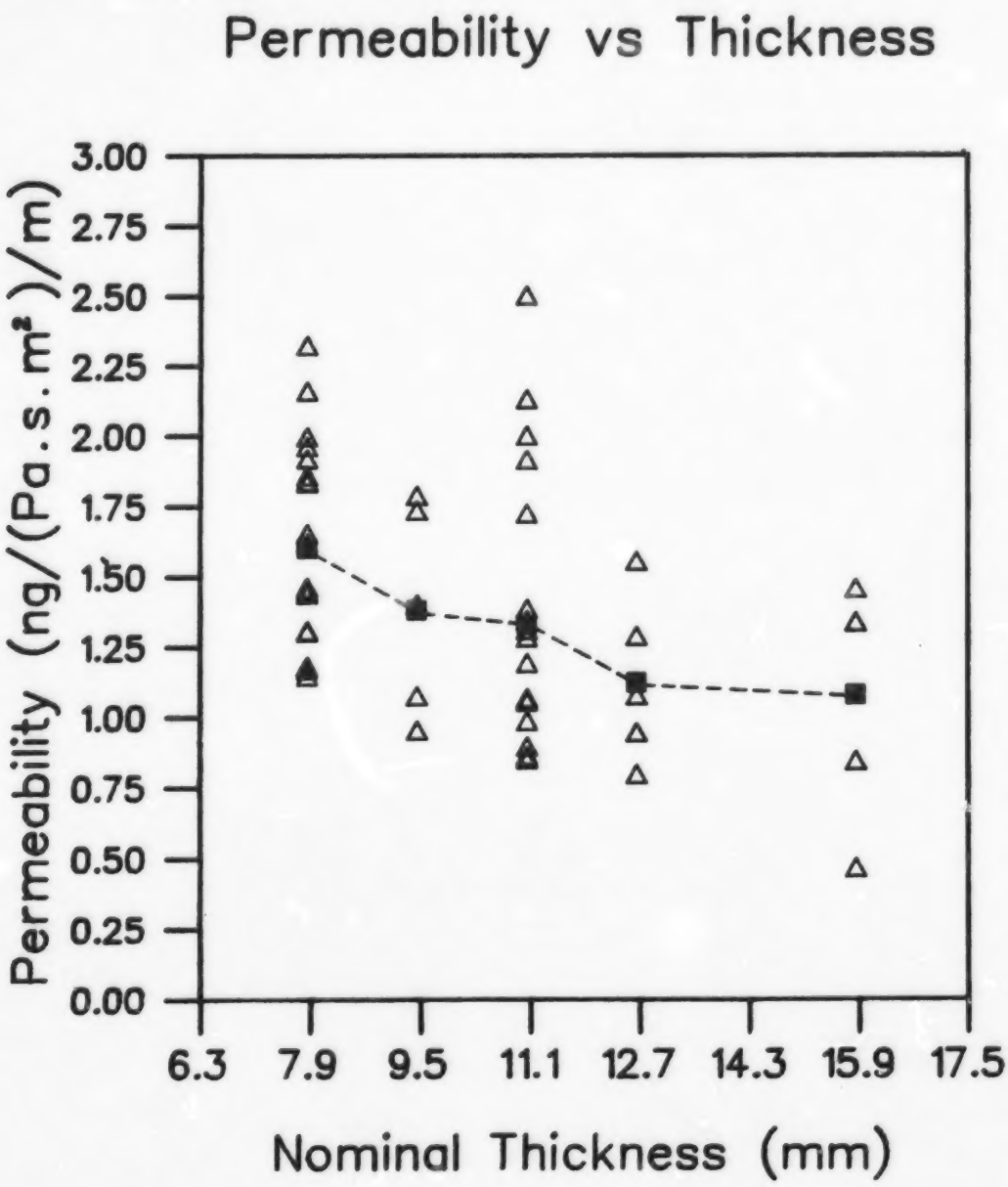


Figure 9. Wet-cup permeability for five thickness of oriented waferboard from Mill A

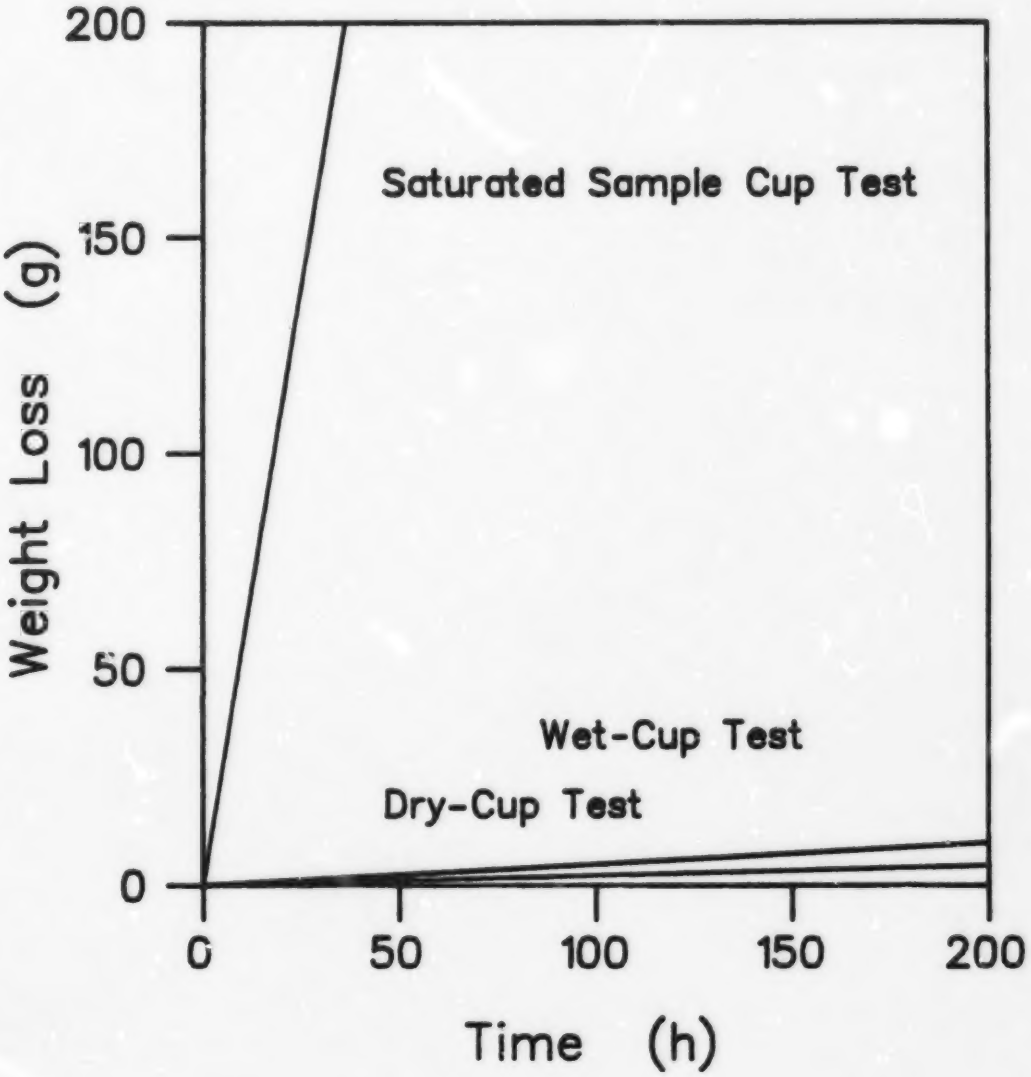


Figure 10. Typical relative weight loss curves for the three test types used in this study